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Project ULTRA, Unlimited Training for All, is founded on the assumption that through a systems approach to education, a model educational system will evolve which can be implemented on a mass basis. The inventory and potential of each individual in a heterogeneous population would be matched to his subsequent career environment. The door to educational escalation would never be closed. It should provide the methodologies and resources to develop human talent in an optimal way with a high probability of attainment. A prime objective is to extend the range of college opportunity to students, who, under conventional educational practices, would be deprived of this educational possibility.

Several programs are related to Project ULTRA through a computer-oriented information center: the Diagnostic Examinations Center, where a series of achievement examinations are administered to place students; the Institutional Off-Campus Program, which is composed of industrially related institutions; and the Self-organizing Computer-Based Experimental Programs, which allow for individualized optimal requirements while dispensing with arbitrary time limitations.

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EDUCATIONAL ESCALATION THROUGH SYSTEMS ANALYSIS

PROJECT U L T R A

AT

NEW YORK INSTITUTE OF TECHNOLOGY

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education

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I. THE DIMENSIONS OF THE PLAN

Numerous projects have been initiated within the past few years relating to the educational problems arising as a result of heterogeneous populations. The unique problems of special groups (e.g. high school dropouts, the culturally deprived, the exceptionally gifted) are featured in the press. Present day educational methods and facilities are inadequate to service the needs of groups with common deviations from conventional formalized patterns, to say nothing of the needs of individuals. A carefully formulated educational plan must not only consider the disadvantaged, but also, the advantaged, and must even be responsive to those who are not privileged, or able, to enter the conventional formal patterns of institutionalized learning. It must avoid arbitrary standards, curricula, and decisions, reject the word "rejection", and substitute the concepts of such words as "preparatory", "alternate", and "auxiliary". It must match the inventory and the potential of the individual to his subsequent career environment, and provide the means for adaptation towards an interest goal, with a high probability of attainment. It must provide the resources to develop human talent in an optimal way.

A program with these dimensions must be self-improving: therefore flexible.

II. TEACHING SYSTEMS AT THE NEW YORK INSTITUTE OF TECHNOLOGY

A prime objective of the New York Institute of Technology is to assist in the solution of the problem of providing skilled technical support personnel. Since 1958, it has been engaged in a continuous intensive program of research and experimentation on the applications of individualized instructional learning techniques and auto-instructional systems for education at the collegiate level.

Researchers at the Institute realized that a systems engineering analysis offered a scientific method to the educator for developing new approaches to

one fundamental canon of education: each student advancing at his individually determined rate of progress. Since experiments with differentially-paced programs require a flexible learner time-based system, permission was sought from the Division of Higher Education of the New York State Department of Education to conduct learner time-based auto-instructional programs. In 1960, authorization was granted to

> "conduct an experimental program in which the teaching machines would become a part of the teaching process and the students participating in the program would have the privilege of sitting for examinations and earning credit when they are ready for an examination . . . with the understanding that . . . the work would be given in academic areas which lend themselves to machine teaching such as electronics, mathematics, physics, and other technical courses. . ."

In any differentially-paced system, the quality of instructional materials is obviously of overwhelming importance. The most intricate system of automated learning aids is irrelevant without reference to the quality of the instructional programs. Accordingly, the generation of extensively validated programmed instructional material has been a continuous requirement of the experimental programs at the New York Institute of Technology.

The preparation and validation of programmed texts has been only one element in the NYIT research and experimentation in differentially paced teaching subsystems. Restriction to one technique might impair attainment of the desired objectives. If we want individuals to be able to make original applications of what they learn, to be able to solve problems creatively, to make leaps from the basic acquired knowledge to applied areas, to transfer through generalization of response, flexibility in stimulus input as well as response mode is essential. The programming methods developed by NYIT are adaptable to multichannel sensory inputs and response modes. Thus, a wide variety of media are being utilized, e.g., television, video tape, records, models, etc., to stimulate the visual, auditory, and kinesthetic senses. Utilizing the powerful reinforcement principles identified in the learning laboratories, subject matter is presented in units to the learner in such a way that response error

under controlled conditions is possible, and multiple channel sensory inputs as well as multiple response modes are employed.

The Institute has developed and equipped a teaching systems laboratory of 150 student stations. Support equipment includes a 1620 computer, closed circuit television, four TV video tape recorders, one hundred Autotutors, automated test devices, and a wide range of audio-visual materials and equipment as part of the teaching laboratory.

In 1963, the Institute was awarded a grant by the Carnegie Corporation of New York to develop a model system for the education of engineering technicians.

The Carnegie Project, currently underway, has provided the basis for the development of PROJECT ULTRA (UnLimited TRaining for All). Project ULTRA is a direct extension of the work to date, the evolving system being extended to cover industrial, health, commercial, and other career oriented specialties and their related vocational fields, all being integrated into a collegiate program. Hopefully, it will provide the means for continuous escalation through continuing educational cycles.

Project ULTRA is founded on the assumption that, through a systems approach to education, the analysis of the numerous facets and problems of education will provide an integrated solution that is orderly, accepts special cases, and matches the needs of the individuals to the requirements of society.

III. THE PHILOSOPHICAL RATIONALE

Prior to a fuller explanation of the operation of the system, an explanation of the philosophy that lay behind its development may be of value.

The modern pedagogue, whatever his level of involvement may be, must meet an almost unprecedented challenge. We live in a world where exponential expansion of knowledge, scientific breakthroughs, jets, computers, and space exploration are commonplace. Our conversations and knowledge range from broad cultural themes through atomic fission to the chemistry of life. Each day, our teachers are faced not only with the problem of transmitting the new knowledge,

but the awesome responsibility of guaranteeing that the young people in their trust actually understand it all. Further, they must not only equip these young men and women with the values and abilities to use this knowledge, satisfying both individual aspirations and the world's needs, but must also develop in them a state of mind which, through analysis and synthesis, relates pertinent material to pragmatic use. The educational problems are so complex, and the needs so severe, that we no longer dare to allow the teacher to work alone and unaided.

The devoted dedication that almost all teachers bring to their task is not enough to satisfy the problems which exist today. In the many sectors of human endeavor, the field of education is among the last to which technology has made any truly substantive contribution. There now exists, in terms of present efforts to modernize the educational structure, an urgency to provide appropriate technological and managerial measures, sufficient to support the resources and dedication offered by the human teacher. Without the application of sophisticated technology, it is difficult to see how the teachers of today, small in number in proportion to the enormous student population, will be able to lead each student to explore, to learn, to evaluate and to master the prodigious quantities of evolving knowledge.

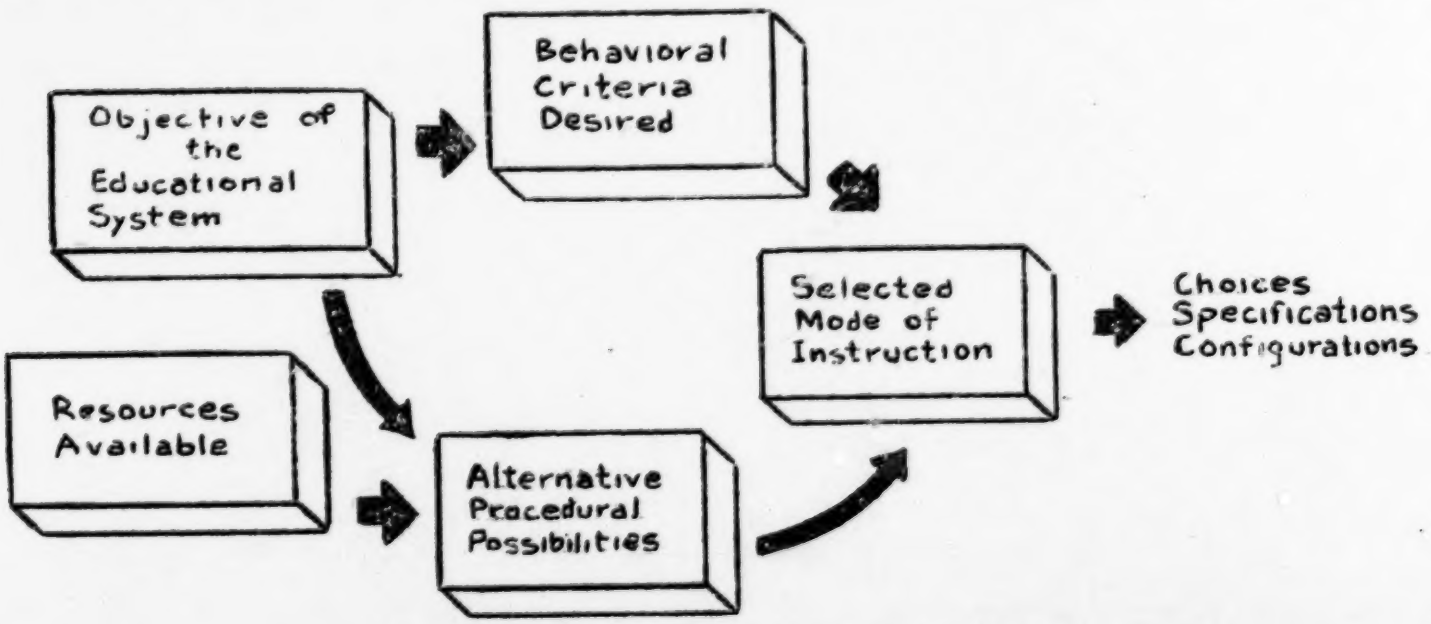
The purpose of interjecting technology into education is to come up with an efficient, meaningful division of labor between men and machines, subject always to the rational control of the human being. Once we have done this, we have an opportunity to expand the benefits that human personalities bring to the process of education, and through technology to relieve much of the rote work which normally restricts use of the human values.

The systems approach, particularly as it relates to educational technology, is not just a collection of hardware - it is much more. It is a social activity involving people, ideas, methods, machines, communications and various interacting systems. But always, it comes back to people. Utilization by people

is always the prime objective. The responsibility for the design and operation of the systems proposed herewith relates both to the professionals who practice in the educational world, and to their students.

IV. THE SYSTEMS APPROACH TO EDUCATION

Systems engineering analysis offers a scientific method to the educator for the organization, statement, and derivation of alternative possible solutions to the many complex problems of education. Its techniques require precise stipulation of objectives, resources, alternatives, and criteria. Proposed modes or methods of organization then may be derived and structured. The selected mode permits the allocation of various choices to be applied to a particular problem. It may also infer new techniques, equipment, and facilities better suited to a specific objective. The systems approach to education utilizes an overall view, regarding an educational operation as a dynamic, interrelated entity and not merely as a collection of elements. The systems engineer looks beyond detailed procedures, checking solutions to entire problems, thereafter working out several theoretical solutions. Subsequently, "paper systems" are structured, simulated and proven. The most efficient is then selected. The diagram below shows a grossly simplified educational systems organization, giving the relationship leading to the structuring of a new mode.



Simplified educational system analysis.

The systems approach to education does not restrict itself to a single path by which optimal education is given to a student population. Its strength lies in the analysis of alternate pathways through which the desired terminal objectives may be attained. Once such systems or sub-systems are organized with objectives which are accurately specified and clearly defined inputs, the multiplicity of pathways or transforms relating the output to the input are subject to alteration as information is accumulated in the analysis and implementation of the system. For an educational prototype, provision for self-improvement by continuous feedback of information relating advanced stages of a task to earlier stages is essential, and a model must possess flexibility.

Sub-system analysis may stipulate sub-system objectives. For example, a novel methodology may be the subject of a separate research task which seeks to obtain maximal utilization of faculty skills, an improvement of the learning rate of students, an opportunity for each student to realize his abilities at his optimum individual pace, and which seeks to control the content and quality of curriculums. The transforms by which these partial objectives may be realized are not necessarily restricted to a unique technique, but may range from use of a combination of media for mass instruction including components (such as video tape) to selected media for individual instruction (such as language laboratories, programmed learning and other individual response systems). It may require the integration and application of teaching teams, related technical personnel, machines, and programmed or sequenced materials. Since the aim is greater productivity without sacrificing standards of quality, it involves the use of labor-saving devices such as teaching machines, which constitute one factor within the "sub-system"; and computers for rapid data acquisition and analysis. The sub-system should be self-improving, based on constant feedback of information at all stages.

A complete system, suitably designed, would contain not only the mass and individual instruction processes but would have the other features described

above, including the teaching teams, the opportunity for individual study, and the use of computers for administrative and instructional purposes. Concurrently, there should be associated organizational activities. These would include research, materials developing and testing, constant teacher training and upgrading designed to take advantage of modern techniques and to give familiarity to new materials. Above all, there must be continuous "quality control" surveillance of the entire system to insure that the desired results are being obtained.

In time, the state of the art may make possible attainment of a completely computerized system, where all the activities discussed above for the actual processing of the student could be computerized. Pending the attainment of this "ultimate" system, and recognizing the present state of the art, the evolution of any study or project could develop an "intermediate stage" of such a system by the use of independent and discreet sub-systems.

Much of the present day formal classroom system is a "batch system". Herein, a group of approximately thirty students of competence ranging over some spread, are brought together to accept instruction from a single teacher. This method is forced upon the school administration because present day economics and logistics do not permit a one-to-one student-to-teacher ratio. Yet, there exists an advancing technology utilizing automated and computerized systems. Through it, it becomes possible to approximate this one-to-one ratio by taking segments of the instructional load and turning it over to a computer, enabling the use of the one-to-one ratio interaction wherever and whenever it is feasible to use it. At the same time, we gain certain by-product advantages in the recording of the students' response in tests, the automatic classification of his response according to predetermined norms, and the subsequent feeding of new instruction according to his successful absorbtion of the preceding material. Paradoxically, systems technology yields individualization, in contrast to the usual impact of machine technology which gives "mass production".

By effectively relieving the teacher of the burden of grading and analyzing each student's performance, and by its capacity for rapid data acquisition and analysis, the computer, in conjunction with auto-instructional teaching devices, makes possible, even on a mass basis, the dream of the educator to adopt a truly differentially paced system, which permits each student to learn at his optimum rate.

V. DESCRIPTION OF ULTRA

Recent studies of the American High School students (Project Talent) have revealed some significant information. In the final report (1964) of Project Talent (based upon the National Survey by the University of Pittsburgh under a research contract with the United States Office of Education) the following quotation appears (P.1-1):

> "It is clear that the overwhelming majority of high-school students at the present time conceive of the major purpose of secondary education as vocational training (using that term in its broadest sense) or as pre-vocational training. The traditional conception of secondary and higher education as preparatory for and training in the liberal arts is not shared by any significant percentage of American High School students in the 1960's. To the extent that it is shared by administrators and faculty members of secondary schools and colleges, they are out of tune with the prevailing ideas of their students".

The concern of these young students for career-oriented education is natural in the light of the plight of the unskilled worker of today. Furthermore, obsolescence of skills is a mounting problem. Education is recognized as an answer, but competition for education is becoming acute. Project Talent indicates that 42% of high school graduates entered a 2 or 4 year college within a year after leaving high school. A National Science Foundation study showed that about 25% of boys who do not enter college immediately do so later on.

The educational institutions and facilities are not prepared to accept this influx of career-oriented students. Rejection rates are high, first year attrition of those accepted is high, and society loses a large proportion of that talent of its youth. The prognosis is made worse with the realization that rejection and failure may leave psychological scars of enormous magnitude

in the populace they affect.

Project ULTRA has, as one of its fundamental objectives, the organization of attainable pathways by means of which each individual may expect a high probability of realizing the predicted match of his potential with the occupational and school inventory. There is no outright rejection of any individual who is willing to improve his education towards a career-oriented objective, although such individual may be directed towards a lesser objective, if his demonstrable abilities at a particular time yield a low predictive probability of success for his original destination. Alternate Skills Programs (ASP), Auxiliary Training Programs (ATP), College Preparatory Programs (CPP), Institutional Off-Campus Programs (IOFF), Deficiency Correcting Phase-In Programs (P.I.), Industry-College Cooperative Associations Programs (C-B), Differentially-paced, Self-organizing Computer-Based Experimental Programs (X), and others are all related to a mainstream program in Project ULTRA through a computer-oriented Information Center (I.C.). The Information Center is part of the central nervous system which receives data from all sources as an ongoing process. It stores, analyzes, retrieves, and distributes information to cortical locations (e.g. the Admissions Center (A.C.), the Diagnostic Examinations Center (D.E.C.), etc.) where convergence and decision making processes are reflected in efferent responses to activity areas and programs. A computer-oriented Information Center is essential to handle the volume and processing of the data required for the integrated operations of Project ULTRA. The feedback of information from advanced program stages provides the source for restructure of predictive elements in the I.C. for self-improvement. Figure I is a schematic outline of the overall concept of ULTRA. The concurrent paths and feedback loops (especially to and from I.C.) may create an impression of complexity which is not inherent in the fundamental concept of the plan. This assertion will be elucidated as selected items and paths are isolated and diagrammed, then referred to Figure I for relationship to the integrated scheme.

V.(a) Behavioral Objectives of Project ULTRA

The purpose of Project ULTRA is to provide for each student the opportunity to receive the education which will qualify him for the career objective selected by his interests and potential abilities, as diagnosed, discussed, predicted, and interpreted by the combined attributes of man-made examinations, computer-oriented methodologies, and man-machine interpretations, with final human decision-making approval.

In order to meet the qualifications for his selected career, these requisites must be defined as precisely as possible. If the objective is a continuation of education in a graduate school, the admissions and standards requirements of all colleges serving the graduate needs in the subject area selected by the student must be summarized, so that a curriculum geared to such needs may be planned. Obviously, unique or specialized requirements of some graduate schools may not be satisfied by the undergraduate curricula of other institutions, but these additional requirements should be spelled out clearly. Although graduate programs may be highly individualized, there are usually basic requisites which may provide a foundation for planning. These include:

1. Type of Baccalaureate Degree
2. Specialization Courses in Undergraduate Curricula
3. General Courses in Undergraduate Curricula
4. Specialization Courses Average
5. General Courses Average
6. Experience or weighting for honors, awards, publications, and other acknowledgements of ability.

These factors are included in Figure I under Graduate School Behavioral Objectives, and are referred to hereafter as the Schools Inventory.

More complicated, however, is the Occupational Inventory. The term is used in its broadest sense, and is not a mere listing of occupational titles. It must be a realistic appraisal of the requisites of employable situations with

which educational institutions must be cognizant. The Job Classifications JI. . . .JN in Figure I correspond to decreasing educational requirement for increasing N. For example, J (N-I) require more training than JN, in general. A coded data card for a given job description may contain a number system to indicate such diverse information as

Degree or amount of education required (e.g. B.S., B.F.A., one year of college, course in first aid, etc.)

Subject area

Specialization courses required

General courses required

Manipulative ability required

Number of employees in equivalent positions in selected geographical locations.

Average starting wage

Potential employers, numbers, sizes of corporations, etc., etc.

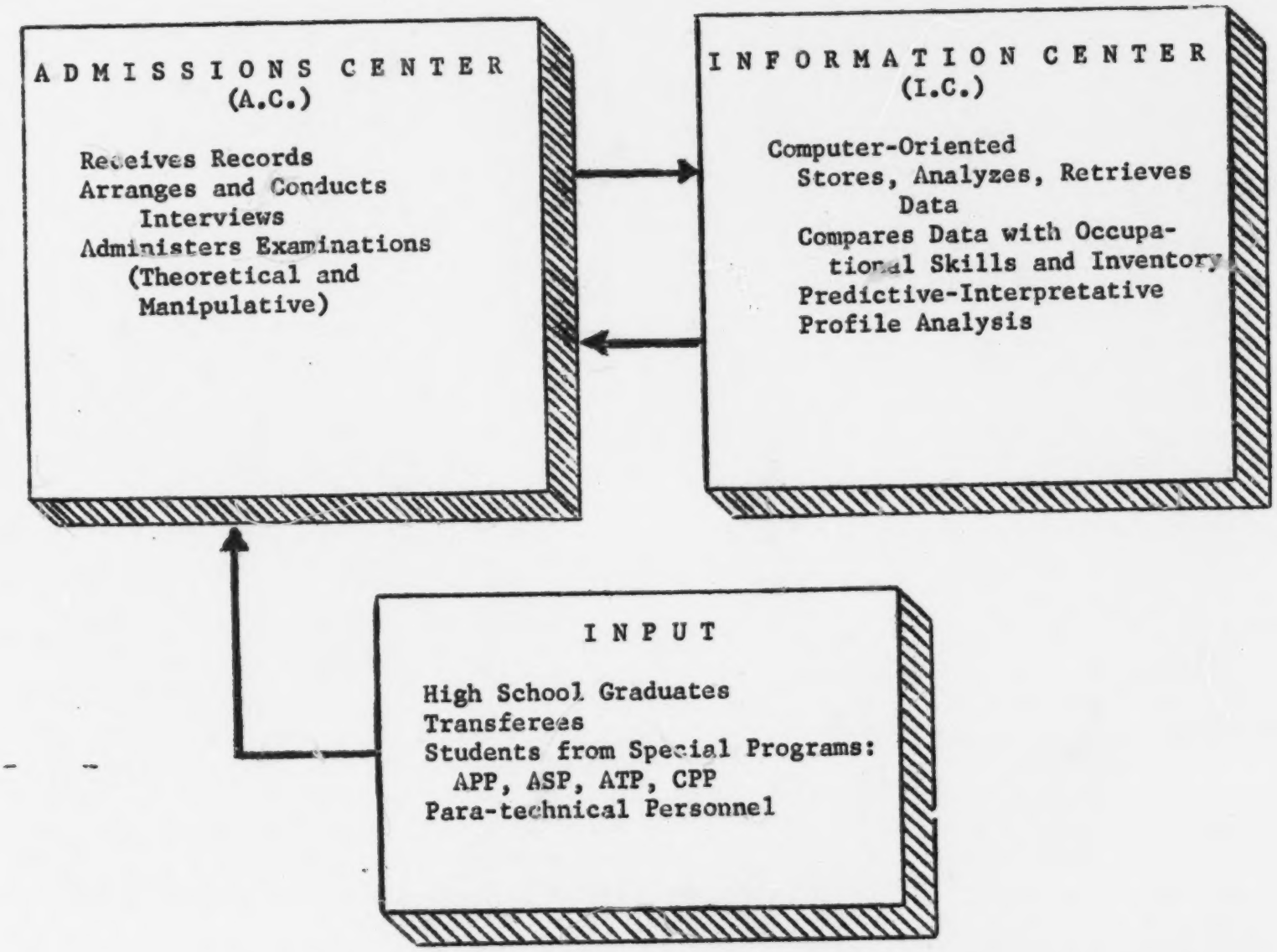
The information must be coded into acceptable computer language and stored in the Information Center. The form of the questionnaire, and the relevance of the data requested to the objective sought requires the cooperative undertaking of governmental, foundational, industrial, and educational experts.

This facet of Project ULTRA will be labelled Occupational and Schools Inventory (OSI).

V.(b) <u>The Input To The System</u>

Diagram A-I below represents a simplification of the Input to the total Educational System, and may be identified in Figure I in its relation to the remainder of the System.

D I A G R A M A - I


A D M I S S I O N S C E N T E R
(A.C.)
Receives Records
Arranges and Conducts
Interviews
Administers Examinations
(Theoretical and
Manipulative)
I N F O R M A T I O N C E N T E R
(I.C.)
Computer-Oriented
Stores, Analyzes, Retrieves
Data
Compares Data with Occupa-
tional Skills and Inventory
Predictive-Interpretative
Profile Analysis
I N P U T
High School Graduates
Transferees
Students from Special Programs:
APP, ASP, ATP, CPP
Para-technical Personnel

The Input presupposes high school graduates, recent, or in occupations for some time, as well as transferees, and others who may not have had the qualifications for admittance into a collegiate program at some previous time, but who, by virtue of additional training and/or experience may have been brought to an acceptable admissions standard. The Admissions Center (A.C.) receives all student records, and arranges and conducts interviews as part of a pre-counselling service. It administers examinations to test college aptitude as well as manipulative and technical skills.

The data are fed to the Information Center which stores, analyzes and retrieves the information using computer-oriented techniques. In addition, the Information Center compares the data with the Occupational and Schools Inventory and reads out a probability prediction of success which is fed back to the Admissions Center. This preliminary information also serves to initiate a profile for the applicant. The Admissions Center (A.C.) receives the comparative and analytical data from the I.C. and a decision is made as to the next possible alternatives.

This will be developed in relation to Diagram A-2 which follows on Page 14.

V.(c) The Diagnostic Examinations Center (DEC), and the Alternate Skills Program

The outcomes of the Admissions Examinations, interviews, and records as analyzed in the computer-oriented Information Center and compared to the Occupational and Schools Inventory serve as a basis for one of two alternate pathways for the applicant to the college. If the predictive probability for success at a collegiate level in an interest area to the applicant is low, then a match is made with an Occupational Classification (J. .) of a related vocational interest in which there is predicted a high probability of attainment. The student is then referred to an Alternate Skills Program for training towards the career-oriented occupational skill (J. .) as diagrammed in A-3 on Page 15.

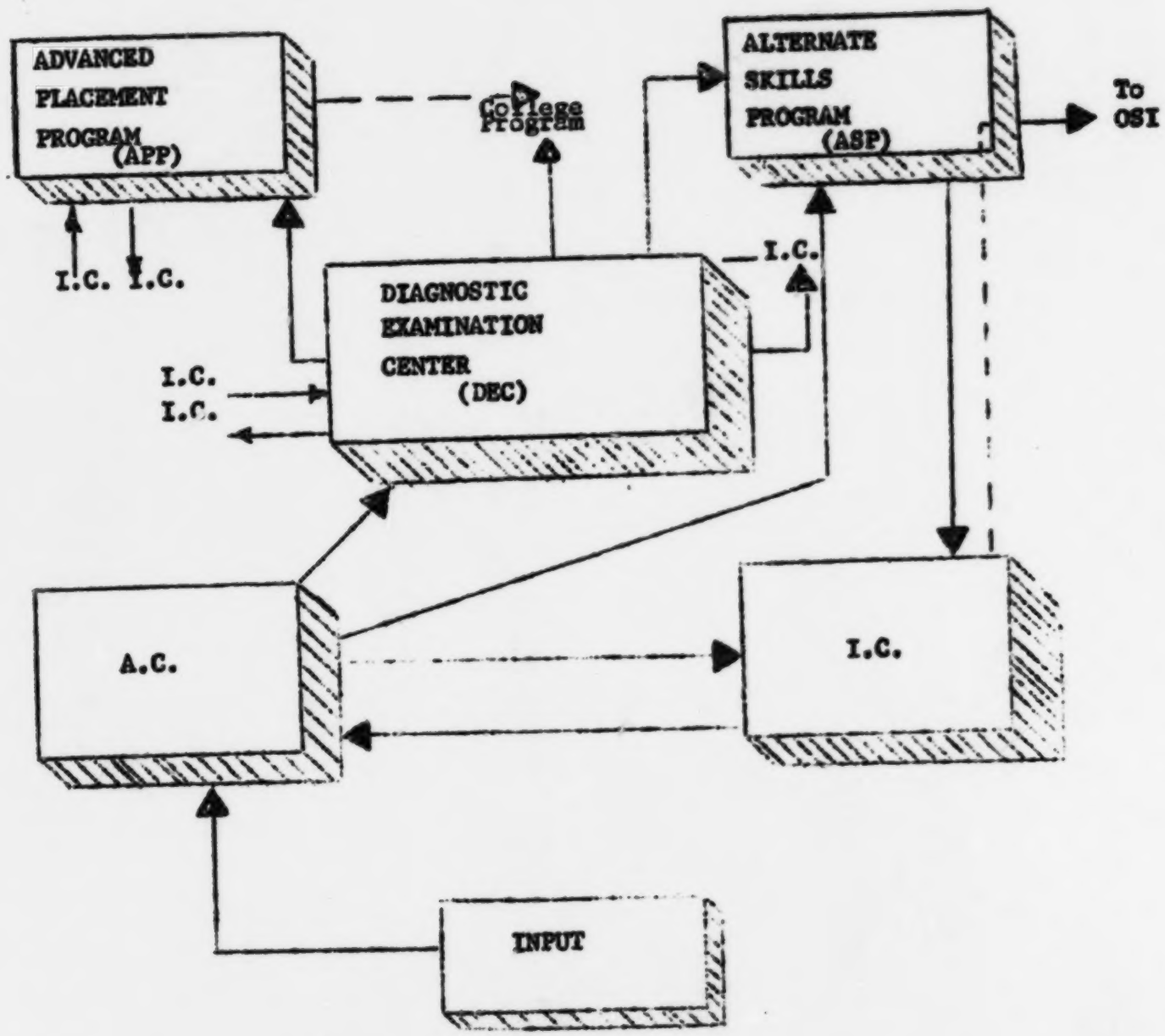

ADVANCED
PLACEMENT
PROGRAM
(APP)
College
Program
ALTERNATE
SKILLS
PROGRAM
(ASP)
To
OSI
I.C.
I.C.
I.C.
DIAGNOSTIC
EXAMINATION
CENTER
(DEC)
I.C.
I.C.
A.C.
I.C.
INPUT

DIAGRAM A - 2

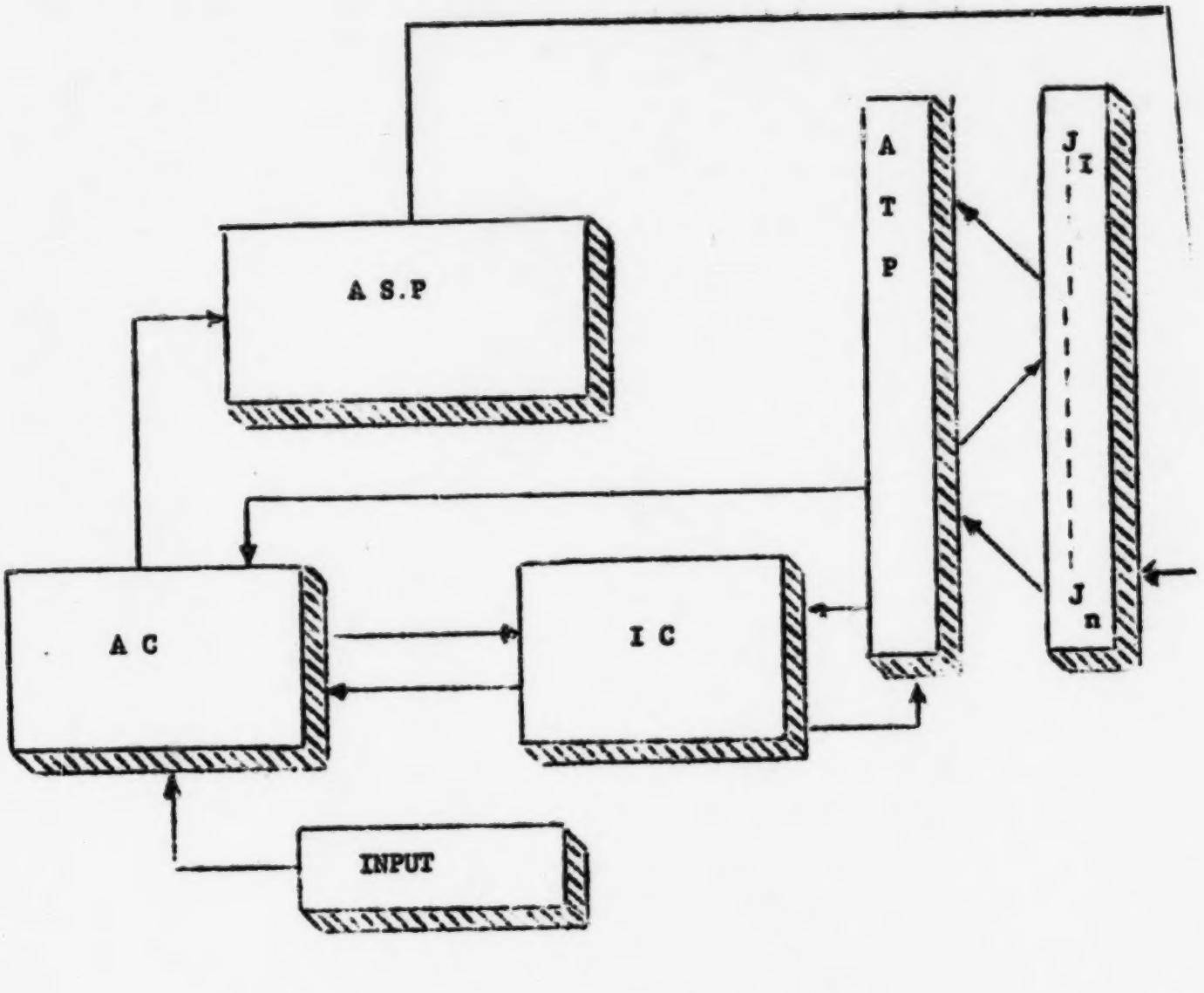


DIAGRAM A-3

The outcome of this training is not limited to successful career training in an area of predicted competence, but, in addition, an opportunity to participate in an Auxiliary Training Program (ATP) which permits re-entrance into the college Admissions Center upon evidence of acceptable achievement. Thus the doors are never closed to the possibility of further educational escalation.

Those students who give satisfactory indications of collegiate potential in the Admissions Center are processed through the Diagnostic Examination Center (DEC). In the DEC, a series of achievement examinations in Reading, English and Associated Skills, and Mathematics and Specialized Subjects are administered. The results of these examinations are again fed to the I.C. where the informational analysis processes are continued, and predictive analytical results returned to the DEC. At this time, one of the following alternate decisions is made:

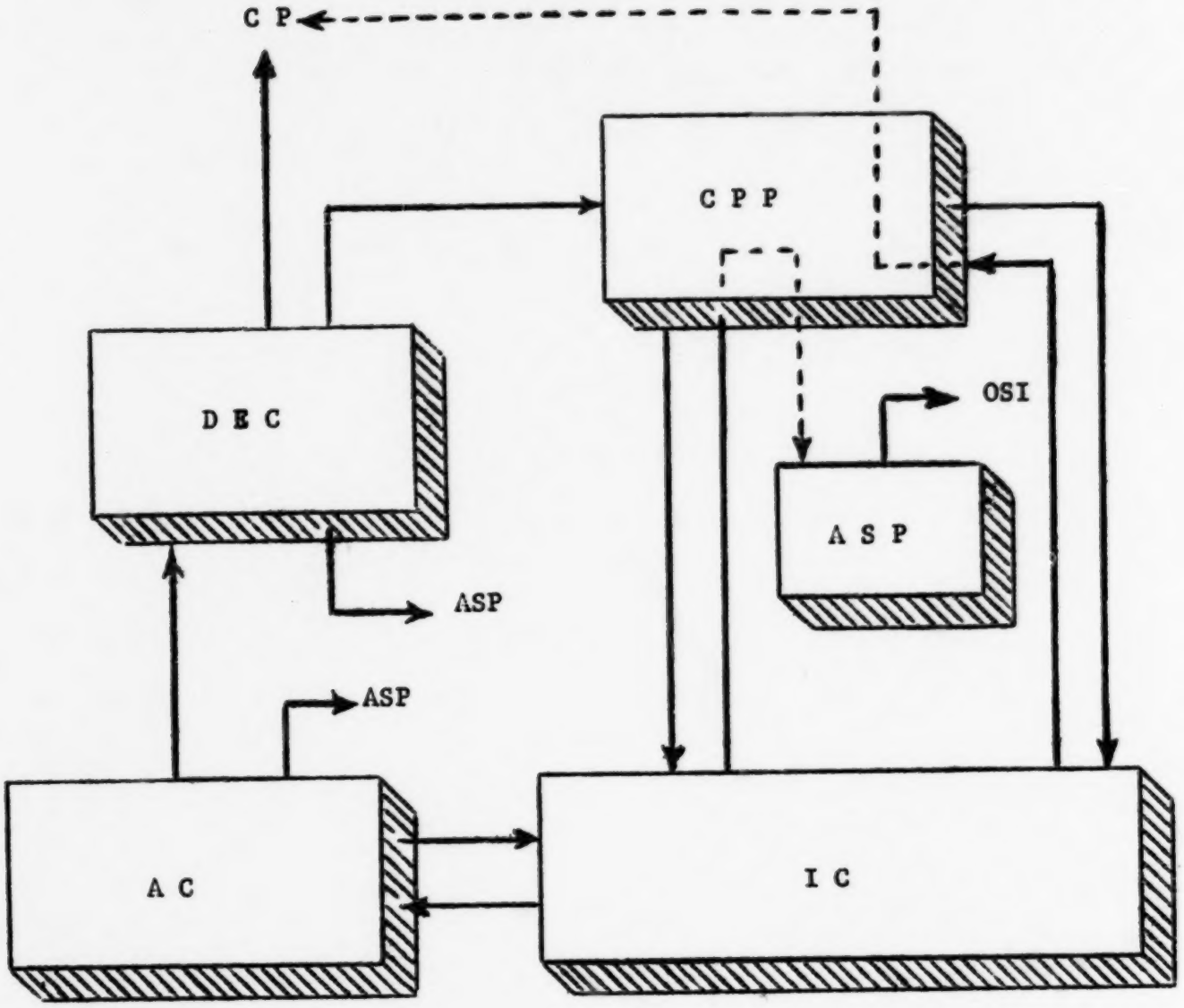
1. The applicant is ready for college training (with or without deficiency phase-in or preparatory programs - discussed later).

2. The applicant is not ready for college training and is referred to the Alternate Skills Program (ASP).

3. The applicant has college training or equivalent which qualifies him for Advance Placement Examinations and subsequent phase-in into the College Program at a more advanced level.

The Diagnostic Examination Center is a key junction in the College Program. It does not reject students from the ultimate possibility of advanced education, but instead, directs them to the appropriate source of training which will yield a high probability of successful outcome. It accepts all special cases, advantaged, as well as disadvantaged, and allows for the variations that are unsuccessfully treated in conventional institutional situations. It spells out hope for the late bloomer, who may be gainfully trained and employed in a less advanced manner until his readiness matures, and it offers a substitute for the outrageous indignity of rejection at a particularly sensitive period of life. Finally, it offers the means by which the great attrition that takes place for those accepted into college programs may be minimized. This contention may be elucidated by referring to Diagram A-4 on page 17.

D I A G R A M A - 4



Those students who are found in the DEC to be deficient in reading comprehension, or any two specialized areas (e.g. English and Math), but who otherwise appear to have the aptitude and ability to benefit from college training will be directed to take a College Preparatory Program (CPP). This program will provide intensive training in fundamental subject areas, designed to bring the student to a collegiate level of performance. The program will be offered during summers for those graduating from High School at the end of the usual high school academic year. Consistent with the philosophy of the overall program, final examination results will be fed to the IC, from which analyzed data will be returned to the DEC to recommend one of the following alternate decisions:

1. Acceptance in the College Program (CP)
2. Direction to the Alternate Skills Program (ASP)

V.(d) DEC and the College Programs

In Figure I, sequential follow-up of those outputs from the DEC to the College Program (CP) show a division based upon A.C., I.C., and D.E.C. outcomes. The Institutional On-Campus Program (ICN) represents the mainstream college program and most closely resembles the more conventional four year sequential baccalaureate programs offered by the majority of colleges and universities. Modern educational methodology and technology are employed, and constant feedback of data to the I.C. is an on-going facet of operation, so that continuous improvement of the educational system is a natural evolutionary process. At any time, based upon performance, interest, or necessity, a student who has satisfied a requirement for a J-classification may leave the system for gainful employment. He may, however, re-enter at a later date, as dictated by his later experience, training, or volition. Upon successful completion of the normal first 2-year sequence of courses, the student is awarded the degree of Associate of Applied Sciences (A.A.S.). At this time, as at any other, he may leave the system to utilize the educational skills he has acquired. The ION

after the AAS program has two alternate curricula, CA and CB. CA is the mainstream and more conventional program which is on-campus in all stages. CB is an institution-industry, institution-laboratory, institution-government, or institution-hospital, cooperative work-education plan, with educational follow-up opportunities available not only to students during their work arrangements, but to the para-technical personnel who may be given the opportunity for escalating their college training.

ION programs in the first year have associated deficiency correction phase-in programs which are unique. Students diagnosed by DEC to be weak in one specific subject area (e.g. English), may attend all other subjects as usual, but in place of the usual English class, the student will be directed to an intensive training course using specialized instructional methods in English. Upon successful passage of diagnostic examinations, given at least twice a year, and geared to the level at which the regular English class is functioning, the student will be phased-into the regular class.

Designation for the special English program is ION minus English (E) plus English Phase-In (EPI), or:

ION - E + EPI

Similarly, there is an ION - Math (M) + MPI, and Phase-In (PI) programs in selected technical areas.

V.(e) Institutional Off-Campus Program - IOFF

It is projected that the impact of both the systems analysis techniques and modern educational technology permit structuring of a total off-campus degree granting program, with emphasis on the technical, industrial, distributive, business, and paratechnical areas. Using authoritarian agencies (collegiate institutions or sources such as the New York State Education Department and the Educational Testing Service Advanced Placement Programs), academic rigor and social value can be built in as an integral part of the new educational design. Students drawn from industry, educated for upgrading within the framework of

the industry, will be given the opportunity to earn a degree, a measure of protection against obsolescence, and a meaningful social status. All are highly desired and urgently needed. One of the objectives of IOFF is the generation of a family of industrially related institutions.

The program should integrate the most successful methodologies known to modern education, including programmed learning, educational television, radio, library and independent study, video and audio tape recordings, correspondence courses, visiting experts, and instructional kits and materials specifically designed for off-campus extension studies. An important feature of the program is the accent upon well-validated computer-oriented instructional materials, coupled with rapid analysis of student performance, and keyed to remedial or accelerated study. Each student proceeds at his or her individual optimum rate, and has access to additional comprehensive resource material as desired or recommended.

The Student Group

There are various categories of the population suffering from higher education deprivation who will constitute the expected heterogenous student body. Wage earners whose working hours conflict with on-campus class schedules, housewives with family ties, and minority groups with financial and other burdens are but a few of these groups.

Cultural and economic advancement for the individual are becoming increasingly dependent upon higher education. No person should be deprived of an opportunity to obtain college training because of the necessity of earning a livelihood, financial burdens, or minority association. High quality off-campus college education is a feasible solution because of modern educational innovations.

V.(f) The Self-Organizing, Computer-Based System of Education (Program X)

Program X is an outgrowth of the pattern of research resulting from the

recent grant awarded the New York Institute of Technology by the Carnegie Corporation of New York. In structuring the model system for the training of engineering technicians, one offshoot has been the development of a self-organizing, computer-based educational system. In it, a computer makes diagnostic examinations of a student's level of knowledge, feeds him the learning materials he requires, checks his progress, and helps him to achieve successful completion of the objectives specified for a particular course. The computer attempts to compute his already acquired knowledge as a starting point for further instruction, and also attempts to indicate his capacity to perform. The student pupil profile constructed by the computer is based upon recognizing both knowledge and determined capabilities or characteristics of the student.

The individual diagnosis permits a student or participant to enter a learning situation at that point most closely related to his needs and capacity to perform. Having discovered the precise point of a student's level of knowledge in a given subject, the computer selects his appropriate learning resources - the lectures and seminars he should attend, the best texts for him to study, the best books for him at the library, the films for him to see.

In this self-organizing learning method, the computer then sets up a mechanism for checking the learner's progress according to his stipulated objective, whether it be to complete credits for a degree course, satisfy a need for continuing education, update his professional background, or reach a level of technical skill. The student is ready to leave the system, without restriction to artificial time limitations, when he has satisfied his objectives.

The self-organizing system permits critical examination of the 'unalterable truths' under which many present educational systems now operate. These include the fixed student-teacher ratio, the assumption that the number of years determines student educational attainment, and the belief that present curriculum patterns meet widely diversified student needs. With the assistance of computers, students in the schools to come will organize their own curriculums.

The computer in the system serves to acquire data and rapidly analyze the student's progress and rate of progress, his difficulties and patterns of difficulty. In conventional classroom situations, patterns of difficulties exhibited by students may not be apparent for weeks or months. By the time the difficulties are uncovered, it may be too late to effect adequate remedial measures. The loss of student time is irrecoverable. Utilizing computer diagnosis, difficulties may be revealed within the course of a single period or at most a few periods, and rapid, effective remedial measures may be undertaken. On the other hand, as patterns of accomplishment are revealed, accelerated measures for advancement may be instituted.

The development of a self-organizing, computer-based system yields the kind of system that tailors an educational program to meet a specific individual need. There are normally two kinds of goals common in educational organization. One arrangement is the typical formal curriculum that exists in our conventional institutions. For example, should a student in high school or in college elect a specifically oriented program he (or she) will, at the conclusion of a finite time, take a series of objective examinations. The results, coupled with other evaluations made by teachers in the classroom, are used to determine competency in that subject. In both high school and college this kind of formal authoritarian structure is amplified to include a number of required courses leading to either a diploma, a degree, or to some professional objective. There is another type of educational organization where this structure and responsibility is either less evident or completely absent. In the wide gamut of continuing education, whether the impetus be social or concerned with the upgrading of a technical or a professional skill, the objectives are less formal. Such goals, if stated at all, are usually less precise than in the formal educational system, and most often are evolved by the learner in the system. Thus, a practicing physician who wishes to stay abreast of the field may say: "I must have certain knowledge relating to a new kind of drug". He has now formulated

his objective and proceeds to organize his own method, entering the educational system to do a number of things to satisfy the need he has expressed. For example, singly or in combinations, he may attend a seminar being given by a professional group, or use the resources of the best available libraries, or ask his colleagues about the persons or goups having the most knowledge relative to his problem, visiting these people in order to get the specific information he desires. The moment he has satisfied his defined objective he says: "I may now leave the educational system for the moment, having completed this particular task."

Education is not really a series of separate little compartments of knowledge. Over the last decade this belief has been shaken, steadily and progressively, throughout school and college organizations founded upon recurring quarter, semester, or annual intervals. The concepts of advanced collegiate placement, non-graded classes, dual-progress schools, and multitrack programs are evidences of an increasing orientation towards non-routinized pupil time organization.

It is only when full range is given to the flexibility of schedule inherent in a fully adaptive and differentially-paced teaching mode that the capability of the mode to react to various pupil differences - or to situational exigencies - becomes primarily related to one single factor - time. This is the truly revolutionary quality of an adaptive teaching mode, replacing the rigidity native to outworn patterns of scheduled routinized learning by a flexible, learner-time based system.

The hypothesis put forth in organizing the computer-based system is that it is perfectly possible to design a system, aided by the computer, where, with great precision, the satisfaction of defined objectives can be met. Here the computer can guide not only the student, but in addition all those concerned with the student, including among others, the teacher, the professional guidance counselor and the psychologist. The system declares precisely and exactly what it is that the student is accomplishing, and the learning experiences that he should undertake to complete the particular educational task he has in mind.

The description which follows stems from the experimental operation of such a system, and its application, at the New York Institute of Technology. It relates to courses now being given in college physics and will give an understanding of how the system works in practice. The teams responsible for evolving the "software" - or programs - structure their materials in accordance with specific goals defined by responsible faculty members in the Physics Department. These objectives are normally specified as heuristic in nature. In effect, they tell the learner embarking on a freshman course in the theory of physics that he is expected to be able to solve a number of mathematical and conceptual problems relating to physics, and that once he has demonstrated his capacity to do so, he has completed the course for formal credit. The student's progress through the course is purely individual. A series of diagnostic examinations is organized to test the knowledge of each student who enters the system. He takes this series on special apparatus which automatically translates the information in a form that may be fed into the computer (a 1620 IBM). The computer makes a series of analyses including the structuring of a pupil profile pattern, and integrates these tests with prior indices of performance, such as I.Q., reading level, and mathematical capacity of the student. It then projects, in terms of such measures, the areas in physics in which the student has achieved competence, the segments in which further learning is required because of demonstrated deficiencies, and the specific institutional resources available to the student to help meet the objectives for that unit.

As an example, if the student were concerned with learning something as simple as the fundamental units relating to measurements, the computer would produce a routine record outlining all of the institutional resources and materials available to the student to supplement the demonstrated areas of deficiency relating to the use of such measurement units. This record would include additional study programs, references to textual material in the library, available films or video tape recordings, pertinent seminars or lecture classes

offered by professors in the department, the times these are available, all as they relate to this learning objective. along with final diagnostic post tests to verify the student's progress. A student, in accordance with his attitudes, capacities and desires, chooses from among these resources and organizes his own schedule of learning. The computer may indicate suggestions derived from the attitudes of the student, but the responsibility for organizing his educational program remains with the learner. He may choose from among the available resources those which are sufficient to bring him to the next point stipulated in the objectives defined for the course. It is stressed that he may select any resource he chooses, including the human resources available in the faculty, to the extent he desires, as available within the institution. Whenever he meets the final "terminal" objectives put forth for the particular course, he has completed that course. He then "leaves" the learning system, in the sense of having no further needs relating to this course.

The mechanism for meaningful independent study thus allows a more complete utilization of the human resources of both the student and his educational institution. Experimental work to date has indicated a major reduction in the time necessary to complete typical courses in degree curriculums. The computer-oriented program may make possible individual education on a mass basis, within or outside universities and other formal educational institutions.

The sub-systems comprising the first two collegiate years of Program X are currently under development with the support of the grant by the Carnegie Corporation of New York. Its computer-oriented, differentially-paced program dispenses with arbitrary time limitations, and allows for individualized optimal training. Project ULTRA seeks to extend this program to include all baccalaureate requirements. Project X, an experimental program today, already shows sufficient promise as a serious contender for an ultimate optimal educational system to warrant extensive investigation.

V.(g) Occupational and Graduate School Followup

Refer to Diagram A-5 which follows on Page 26.

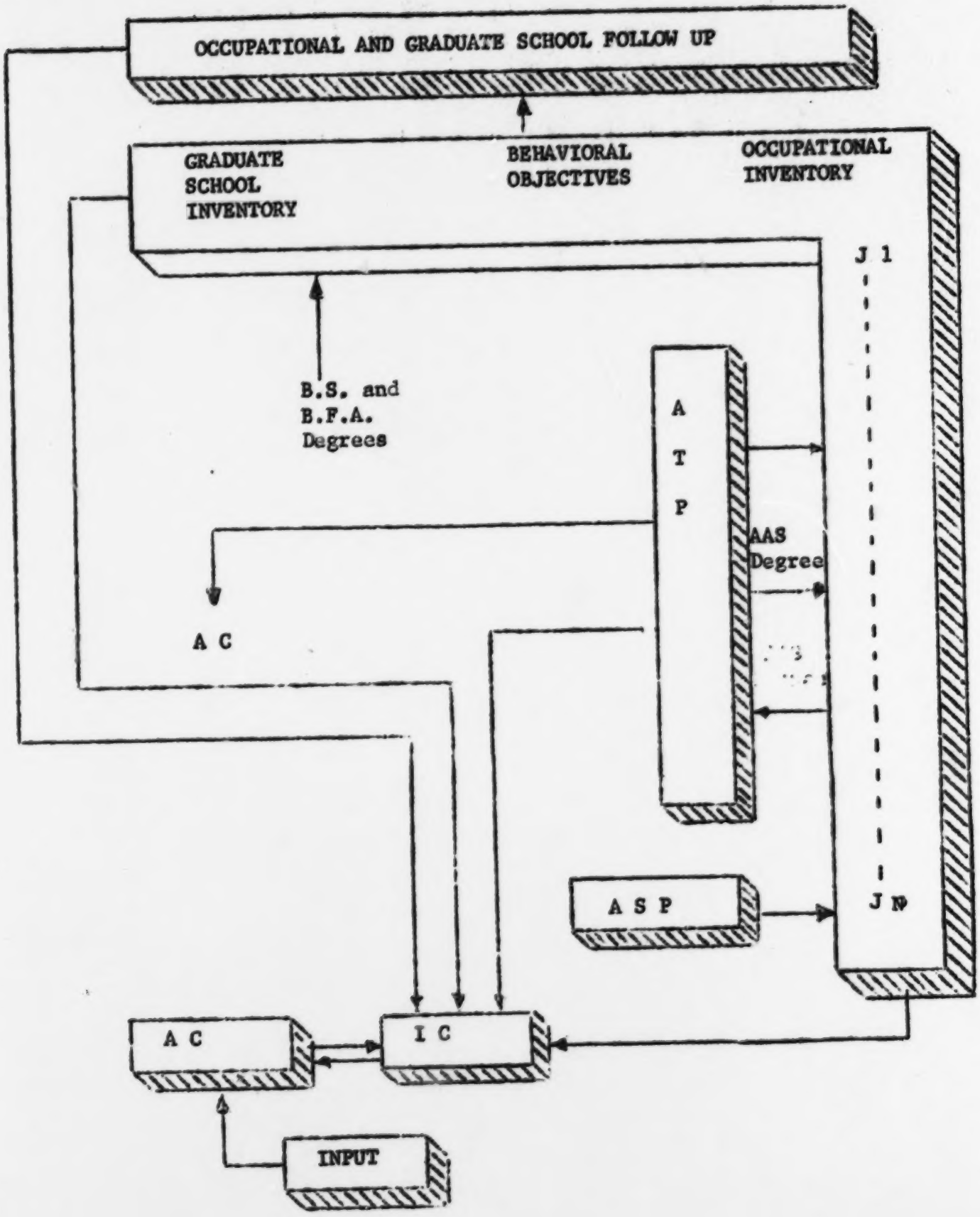

OCCUPATIONAL AND GRADUATE SCHOOL FOLLOW UP
GRADUATE SCHOOL INVENTORY
BEHAVIORAL OBJECTIVES
OCCUPATIONAL INVENTORY
J 1
B.S. and B.F.A. Degrees
A T P
AAS Degree
A C
A S P
J N
A C
I C
INPUT

DIAGRAM. A-5

V. (h)The Occupational and Schools Inventory is a prime influence on the evolution of educational curricula and standards. It is the basis of the predictive methods against which college applicants are judged. Therefore, it must be constantly reassessed for its soundness. The occupational and graduate school followup study is one means by which this check is made possible. Diagram A-5 indicates the feedback of representative check data to the Information Center. The feedback loops may be traced for several programs.

VI. SUMMARY

Project ULTRA is founded on the assumption that through a systems approach to education, a model educational system will evolve that can be implemented on a mass basis, yet match the inventory and potential of each individual in a heterogeneous population to his subsequent career environment and never close the door to educational escalation. It must provide the methodologies and resources to develop human talent in an optimal way and with a high probability of attainment. A prime objective of the project is to extend the range of college opportunity to students, who, under conventional educational practices, would be deprived of this educational possibility.